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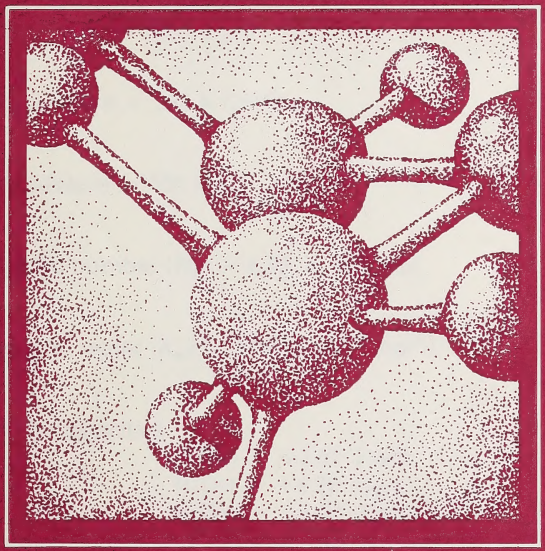

CHEMISTRY DATA BOOKLET

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CHEMISTRY

MISCELLANEOUS

$H_2O(s) \longrightarrow H_2O(l)$ $\Delta H = +6.03$ kJ

$H_2O(l) \longrightarrow H_2O(g)$ $\Delta H = +40.8$ kJ

Room temperature = 298 K (25°C)

Standard pressure = 101 kPa

The Avogadro number (N_A) = 6.02×10^{23}/mol

Ion product for water (K_w) = 1.00×10^{-14} mol^2/L^2

Specific heat capacities:

$H_2O(s)$ = +2.01 J/(g•°C)
$H_2O(l)$ = +4.19 J/(g•°C)
$H_2O(g)$ = +2.01 J/(g•°C)

Speed of light (c) = 3.00×10^8 m/s

Charge of 1.00 mol of electrons = 9.65×10^4 C

STANDARD HEATS OF FORMATION

NAME	FORMULA	ΔH_f° (kJ/mol)
aluminum oxide	$Al_2O_3(s)$	−1669.8
ammonia	$NH_3(g)$	−46.2
ammonium chloride	$NH_4Cl(s)$	−315.4
ammonium nitrate	$NH_4NO_3(s)$	−365.1
barium carbonate	$BaCO_3(s)$	−1218.8
barium chloride	$BaCl_2(s)$	−860.1
barium hydroxide	$Ba(OH)_2(s)$	−946.4
barium oxide	$BaO(s)$	−558.1
barium sulphate	$BaSO_4(s)$	−1465.2
benzene	$C_6H_6(l)$	+82.9
butane	$C_4H_{10}(g)$	−124.7
calcium carbonate	$CaCO_3(s)$	−1206.9
calcium chloride	$CaCl_2(s)$	−795.0
calcium hydroxide	$Ca(OH)_2(s)$	−986.6
calcium oxide	$CaO(s)$	−635.5
calcium sulphate	$CaSO_4(s)$	−1432.7
carbon dioxide	$CO_2(g)$	−393.5
carbon monoxide	$CO(g)$	−110.5
chromium(III) oxide	$Cr_2O_3(s)$	−1128.4
copper(I) oxide	$Cu_2O(s)$	−166.7
copper(II) oxide	$CuO(s)$	−155.2
copper(II) sulphate	$CuSO_4(s)$	−769.9
copper(II) sulphide	$CuS(s)$	−48.5
ethane	$C_2H_6(g)$	−84.7
ethanoic acid (acetic acid)	$CH_3COOH(l)$	−487.0
ethanol	$C_2H_5OH(l)$	−277.6
ethene (ethylene)	$C_2H_4(g)$	+52.3
ethyne (acetylene)	$C_2H_2(g)$	+226.7
glucose	$C_6H_{12}O_6(s)$	−1273.1
hydrogen bromide	$HBr(g)$	−36.2
hydrogen chloride	$HCl(g)$	−92.3
hydrogen fluoride	$HF(g)$	−286.6
hydrogen iodide	$HI(g)$	+25.9
hydrogen peroxide	$H_2O_2(l)$	−187.6
hydrogen sulphide	$H_2S(g)$	−20.1
iron(III) oxide	$Fe_2O_3(s)$	−822.2
iron(II, III) oxide (magnetite)	$Fe_3O_4(s)$	−1117.1
lead(II) bromide	$PbBr_2(s)$	−277.0
lead(II) chloride	$PbCl_2(s)$	−359.2
lead(II) oxide	$PbO(s)$	−217.9
lead(IV) oxide	$PbO_2(s)$	−276.6
magnesium carbonate	$MgCO_3(s)$	−1112.9
magnesium chloride	$MgCl_2(s)$	−641.8
magnesium hydroxide	$Mg(OH)_2(s)$	−924.7
magnesium oxide	$MgO(s)$	−601.8
magnesium sulphate	$MgSO_4(s)$	−1278.2

STANDARD HEATS OF FORMATION (continued)

NAME	FORMULA	ΔH_f° (kJ/mol)
manganese(II) oxide	$MnO_{(s)}$	−384.9
manganese(IV) oxide	$MnO_{2(s)}$	−520.9
mercury(II) oxide	$HgO_{(s)}$	−90.7
mercury(II) sulphide	$HgS_{(s)}$	−58.2
methanal (formaldehyde)	$CH_2O_{(g)}$	−115.9
methane	$CH_{4(g)}$	−74.8
methanoic acid (formic acid)	$HCOOH_{(l)}$	−409.2
methanol	$CH_3OH_{(l)}$	−238.6
nickel(II) oxide	$NiO_{(s)}$	−244.3
nitric acid	$HNO_{3(l)}$	−173.2
nitrogen dioxide	$NO_{2(g)}$	+33.8
nitrogen oxide	$NO_{(g)}$	+90.4
octane	$C_8H_{18(l)}$	−208.4
pentane	$C_5H_{12(l)}$	−146.4
phosphorus pentachloride	$PCl_{5(g)}$	−398.9
phosphorus trichloride	$PCl_{3(g)}$	−306.4
potassium bromide	$KBr_{(s)}$	−392.2
potassium chlorate	$KClO_{3(s)}$	−391.2
potassium chloride	$KCl_{(s)}$	−435.9
potassium hydroxide	$KOH_{(s)}$	−425.8
propane	$C_3H_{8(g)}$	−103.8
silicon dioxide	$SiO_{2(s)}$	−859.4
silver bromide	$AgBr_{(s)}$	−99.5
silver chloride	$AgCl_{(s)}$	−127.0
silver iodide	$AgI_{(s)}$	−62.4
sodium bromide	$NaBr_{(s)}$	−359.9
sodium chloride	$NaCl_{(s)}$	−411.0
sodium hydroxide	$NaOH_{(s)}$	−426.7
sodium iodide	$NaI_{(s)}$	−288.0
sucrose	$C_{12}H_{22}O_{11(s)}$	−2225.6
sulphur dioxide	$SO_{2(g)}$	−296.9
sulphuric acid	$H_2SO_{4(l)}$	−811.3
sulphur trioxide	$SO_{3(g)}$	−395.2
tin(II) chloride	$SnCl_{2(s)}$	−349.8
tin(IV) chloride	$SnCl_{4(l)}$	−545.2
tin(II) oxide	$SnO_{(s)}$	−286.2
tin(IV) oxide	$SnO_{2(s)}$	−580.7
water (liquid)	$H_2O_{(l)}$	−285.9
water (vapor)	$H_2O_{(g)}$	−241.8
zinc oxide	$ZnO_{(s)}$	−348.0
zinc sulphide	$ZnS_{(s)}$	−202.9

TES: 1. All heats of formation are measured at 298 K (25°C) and 101 kPa.
2. Molar heats of formation for elements in their naturally occurring form are assumed to be zero.

ACID-BASE INDICATORS AT 298 K (25°C)

INDICATOR	pH RANGE	COLOR CHANGE AS pH INCREASES
methyl violet	0.0 - 1.6	yellow to blue
thymol blue	1.2 - 2.8	red to yellow
orange IV	1.4 - 2.8	red to yellow
methyl orange	3.2 - 4.4	red to yellow
bromocresol green	3.8 - 5.4	yellow to blue
methyl red	4.8 - 6.0	red to yellow
chlorophenol red	5.2 - 6.8	yellow to red
bromothymol blue	6.0 - 7.6	yellow to blue
phenol red	6.6 - 8.0	yellow to red
phenolphthalein	8.2 - 10.0	colorless to pink
thymolphthalein	9.4 - 10.6	colorless to blue
alizarin yellow R	10.1 - 12.0	yellow to red
indigo carmine	11.4 - 13.0	blue to yellow
1, 3, 5-trinitrobenzene	12.0 - 14.0	colorless to orange

RELATIVE STRENGTHS OF ACIDS AND BASES

REACTION ITH WATER	ACID NAME	ACID FORMULA	CONJUGATE BASE	K_a
100	perchloric acid	$HClO_4(aq)$	$ClO_4^-(aq)$	very large
100	hydroiodic acid	$HIO_3(aq)$	$IO_3^-(aq)$	very large
100	hydrobromic acid	$HBrO_3(aq)$	$BrO_3^-(aq)$	very large
100	hydrochloric acid	$HCl(aq)$	$Cl^-(aq)$	very large
100	nitric acid	$HNO_3(aq)$	$NO_3^-(aq)$	large
100	sulphuric acid	$H_2SO_4(aq)$	$HSO_4^-(aq)$	large
100	hydronium ion	$H_3O^+(aq)$	$H_2O(l)$	—
53	oxalic acid	$HOOCCOOH(aq)$	$HOOCCOO^-(aq)$	5.9×10^{-2}
32	*sulphurous acid($SO_2 + H_2O$)	$H_2SO_3(aq)$	$HSO_3^-(aq)$	1.5×10^{-2}
29	hydrogen sulphate ion	$HSO_4^-(aq)$	$SO_4^{2-}(aq)$	1.2×10^{-2}
24	phosphoric acid	$H_3PO_4(aq)$	$H_2PO_4(aq)$	7.5×10^{-3}
6.8	**nitrous acid	$HNO_2(aq)$	$NO_2^-(aq)$	4.6×10^{-4}
5.9	hydrofluoric acid	$HF(aq)$	$F^-(aq)$	3.5×10^{-4}
4.2	methanoic acid	$HCOOH(aq)$	$HCOO^-(aq)$	1.8×10^{-4}
—	methyl orange	$HMo(aq)$	$Mo^-(aq)$	$\sim 10^{-4}$
2.5	benzoic acid	$C_6H_5COOH(aq)$	$C_6H_5COO^-(aq)$	6.5×10^{-5}
2.5	hydrogen oxalate ion	$HOOCCOO^-(aq)$	$OOCCOO^{2-}(aq)$	6.4×10^{-5}
1.3	ethanoic (acetic) acid	$CH_3COOH(aq)$	$CH_3COO^-(aq)$	1.8×10^{-5}
0.21	carbonic acid($CO_2 + H_2O$)	$H_2CO_3(aq)$	$HCO_3^-(aq)$	4.3×10^{-7}
—	bromothymol blue	$HBb(aq)$	$Bb^-(aq)$	$\sim 10^{-7}$
0.10	*hydrogen sulphite ion	$HSO_3^-(aq)$	$SO_3^{2-}(aq)$	1.0×10^{-7}
9.5×10^{-2}	hydrosulphuric acid	$H_2S(aq)$	$HS^-(aq)$	9.1×10^{-8}
7.9×10^{-2}	dihydrogen phosphate ion	$H_2PO_4^-(aq)$	$HPO_4^{2-}(aq)$	6.2×10^{-8}
5.4×10^{-2}	hypochlorous acid	$HOCl(aq)$	$OCl^-(aq)$	3.0×10^{-8}
—	phenolphthalein	$HPh(aq)$	$Ph^-(aq)$	$\sim 10^{-9}$
8.5×10^{-3}	boric acid	$H_3BO_3(aq)$	$H_2BO_3^-(aq)$	7.3×10^{-10}
7.5×10^{-3}	ammonium ion	$NH_4^+(aq)$	$NH_3(aq)$	5.6×10^{-10}
7.0×10^{-3}	hydrocyanic acid	$HCN(aq)$	$CN^-(aq)$	4.9×10^{-10}
2.4×10^{-3}	hydrogen carbonate ion	$HCO_3^-(aq)$	$CO_3^{2-}(aq)$	5.6×10^{-11}
3.3×10^{-4}	hydrogen sulphide ion	$HS^-(aq)$	$S^{2-}(aq)$	1.1×10^{-12}
1.5×10^{-4}	*hydrogen phosphate ion	$HPO_4^{2-}(aq)$	$PO_4^{3-}(aq)$	2.2×10^{-13}
1.8×10^{-7}	water (55.5 mol/L)	$H_2O(l)$	$OH^-(aq)$	1.0×10^{-14}
0	hydroxide ion	$OH^-(aq)$	$O^{2-}(aq)$	very small

INCREASING BASE STRENGTH

E: Unless otherwise indicated, all measurements are made at 298 K (25°C) with acid concentrations of 0.10 mol/L (except for indicators, which are not normally used at that high a concentration).

* Temperature = 291 K (18°C)

** Temperature = 285.5 K (12.5°C)

SOLUBILITY OF SOME IONIC COMPOUNDS IN WATER AT 298 K (25°C)

ION	Group IA		NH_4^+	NO_3^-	CH_3COO^-	Cl^- Br^- I^-	SO_4^{2-}	S^{2-}	OH^-	PO_4^{3-} SO_3^{2-} CO_3^{2-}
	alkali metal ions	H^+ (H_3O^+)								
SOLUBILITY OF >0.1 mol/L (VERY SOLUBLE)	All	All	All	All	Most	Most	Most	Group IA Group IIA NH_4^+	Group IA NH_4^+ Sr^{2+} Ba^{2+} Tl^+	Grou IA NH
SOLUBILITY OF <0.1 mol/L (SLIGHTLY SOLUBLE)	None	None	None	None	Ag^+	Ag^+ Pb^{2+} Hg_2^{2+} Cu^+ Tl^+	Ca^{2+} Sr^{2+} Ba^{2+} Ra^{2+} Ag^+ Pb^{2+}	Most	Most	Mos

PERIODIC TABLE OF IONS

TABLE OF COMPLEX IONS

acetate	CH_3COO^-	perchlorate	ClO_4^-	oxalate	$OOCCOO^{2-}$	hydrogen sulphate bisulphate	HSO_4^-
ammonium	NH_4^+	chlorite	ClO_2^-	permanganate	MnO_4^-	hydrogen sulphite bisulphite	HSO_3^-
benzoate	$C_6H_5COO^-$	hypochlorite	ClO^- or OCl^-	phosphate	PO_4^{3-}	thiocyanate	SCN^-
borate	BO_3^{3-}	chromate	CrO_4^{2-}	hydrogen phosphate	HPO_4^{2-}	thiosulphate	$S_2O_3^{2-}$
		dichromate	$Cr_2O_7^{2-}$	dihydrogen phosphate	$H_2PO_4^-$		
bromate	BrO_3^-	cyanide	CN^-				
carbonate	CO_3^{2-}			silicate	SiO_3^{2-}		
hydrogen carbonate bicarbonate	HCO_3^-	hydroxide	OH^-	sulphate	SO_4^{2-}		
chlorate	ClO_3^-	iodate	IO_3^-	sulphite	SO_3^{2-}		
		nitrate	NO_3^-	hydrogen sulphide	HS^-		
		nitrite	NO_2^-	bisulphide			

GROUP IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1 H^+ hydrogen																1 H^- hydride	2 He helium
3 Li^+ lithium	4 Be^{2+} beryllium											5 B boron	6 C carbon	7 N^{3-} nitride	8 O^{2-} oxide	9 F^- fluoride	10 Ne neon
11 Na^+ sodium	12 Mg^{2+} magnesium											13 Al^{3+} aluminum	14 Si silicon	15 P^{3-} phosphide	16 S^{2-} sulphide	17 Cl^- chloride	18 Ar argon
19 K^+ potassium	20 Ca^{2+} calcium	21 Sc^{3+} scandium	22 Ti^{4+} titanium(IV) 22 Ti^{3+} titanium(III)	23 V^{5+} vanadium(V) 23 V^{4+} vanadium(IV)	24 Cr^{3+} chromium(III) 24 Cr^{2+} chromium(II)	25 Mn^{2+} manganese(II) 25 Mn^{4+} manganese(IV)	26 Fe^{3+} iron(III) ferric 26 Fe^{2+} iron(II) ferrous	27 Co^{2+} cobalt(II) 27 Co^{3+} cobalt(III)	28 Ni^{2+} nickel(II) 28 Ni^{3+} nickel(III)	29 Cu^{2+} copper(II) cupric 29 Cu^+ copper(I) cuprous	30 Zn^{2+} zinc	31 Ga^{3+} gallium	32 Ge^{4+} germanium	33 As^{3-} arsenide	34 Se^{2-} selenide	35 Br^- bromide	36 Kr krypton
37 Rb^+ rubidium	38 Sr^{2+} strontium	39 Y yttrium	40 Zr zirconium	41 Nb niobium	42 Mo molybdenum	43 Tc technetium	44 Ru ruthenium	45 Rh rhodium	46 Pd^{2+} palladium(II) 46 Pd^{4+} palladium(IV)	47 Ag^+ silver	48 Cd^{2+} cadmium	49 In^{3+} indium	50 Sn^{4+} tin(IV) stannic 50 Sn^{2+} tin(II) stannous	51 Sb^{3+} antimony(III) stibnous 51 Sb^{5+} antimony(V) stibnic	52 Te^{2-} telluride	53 I^- iodide	54 Xe xenon
55 Cs^+ cesium	56 Ba^{2+} barium	57 La lanthanum	72 Hf hafnium	73 Ta tantalum	74 W tungsten	75 Re rhenium	76 Os osmium	77 Ir iridium	78 Pt^{4+} platinum(IV) 78 Pt^{2+} platinum(II)	79 Au^{3+} gold(III) 79 Au^+ gold(I)	80 Hg^{2+} mercury(II) mercuric 80* Hg^+ mercury(I) mercurous	81 Tl^+ thallium(I) 81 Tl^{3+} thallium(III)	82 Pb^{2+} lead(II) plumbous 82 Pb^{4+} lead(IV) plumbic	83 Bi^{3+} bismuth(III) 83 Bi^{5+} bismuth(V)	84 Po^{2+} polonium(II) 84 Po^{4+} polonium(IV)	85 At^- astatide	86 Rn radon
87 Fr^+ francium	88 Ra^{2+} radium	89 Ac^{3+} actinium	104 Rf rutherfordium Ku kurchatovium	105 Ha hahnium Nl nielsbohrium	106												

58 Ce^{3+} cerium	59 Pr^{3+} praseodymium	60 Nd^{3+} neodymium	61 Pm^{3+} promethium	62 Sm^{3+} samarium	63 Eu^{3+} europium(III) 63 Eu^{2+} europium(II)	64 Gd^{3+} gadolinium	65 Tb^{3+} terbium	66 Dy^{3+} dysprosium	67 Ho^{3+} holmium	68 Er^{3+} erbium	69 Tm^{3+} thulium	70 Yb^{3+} ytterbium	71 Lu^{3+} lutetium
90 Th^{4+} thorium	91 Pa^{5+} protactinium	92 U^{6+} uranium(VI) 92 U^{4+} uranium(IV)	93 Np^{5+} neptunium	94 Pu^{4+} plutonium(IV) 94 Pu^{6+} plutonium(VI)	95 Am^{3+} americium	96 Cm^{3+} curium	97 Bk^{3+} berkelium	98 Cf^{3+} californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium

KEY

atomic number — ion charge (most common or most stable ion listed on top)

26 Fe^{3+} iron(III) ferric

26 Fe^{2+} iron(II) ferrous — symbol

stock (IUPAC) name — classical name

5 B boron

Shaded area indicates this element does not form ionic compounds

*Hg^+ or Hg_2^{2+}

TWO PLACE LOGS

NO.	LOG	NO.	LOG	NO.	LOG	NO.	LOG	NO.	LOG
1.0	0.00	3.0	0.48	5.0	0.70	7.0	0.85	9.0	0.95
1.1	0.04	3.1	0.49	5.1	0.71	7.1	0.85	9.1	0.96
1.2	0.08	3.2	0.51	5.2	0.72	7.2	0.86	9.2	0.96
1.3	0.11	3.3	0.52	5.3	0.72	7.3	0.86	9.3	0.97
1.4	0.15	3.4	0.53	5.4	0.73	7.4	0.87	9.4	0.97
1.5	0.18	3.5	0.54	5.5	0.74	7.5	0.88	9.5	0.98
1.6	0.20	3.6	0.56	5.6	0.75	7.6	0.88	9.6	0.98
1.7	0.23	3.7	0.57	5.7	0.76	7.7	0.89	9.7	0.99
1.8	0.26	3.8	0.58	5.8	0.76	7.8	0.89	9.8	0.99
1.9	0.28	3.9	0.59	5.9	0.77	7.9	0.90	9.9	1.00
2.0	0.30	4.0	0.60	6.0	0.78	8.0	0.90	1.00	0.00
2.1	0.32	4.1	0.61	6.1	0.79	8.1	0.91	1.01	0.00
2.2	0.34	4.2	0.62	6.2	0.79	8.2	0.91	1.02	0.01
2.3	0.36	4.3	0.63	6.3	0.80	8.3	0.92	1.03	0.01
2.4	0.38	4.4	0.64	6.4	0.81	8.4	0.92	1.04	0.02
2.5	0.40	4.5	0.65	6.5	0.81	8.5	0.93	1.05	0.02
2.6	0.41	4.6	0.66	6.6	0.82	8.6	0.93	1.06	0.03
2.7	0.43	4.7	0.67	6.7	0.83	8.7	0.94	1.07	0.03
2.8	0.45	4.8	0.68	6.8	0.83	8.8	0.94	1.08	0.03
2.9	0.46	4.9	0.69	6.9	0.84	8.9	0.95	1.09	0.04

STANDARD ELECTRODE POTENTIALS

Reduction Half-Reaction		$E°$ (V)
$F_2(g) + 2e^-$	$\rightarrow 2F^-(aq)$	+2.87
$PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$	$\rightarrow PbSO_4(s) + 2H_2O(l)$	+1.68
$MnO_4^-(aq) + 8H^+(aq) + 5e^-$	$\rightarrow Mn^{2+}(aq) + 4H_2O(l)$	+1.49
$Au^{3+}(aq) + 3e^-$	$\rightarrow Au(s)$	+1.42
$Cl_2(g) + 2e^-$	$\rightarrow 2Cl^-(aq)$	+1.36
$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^-$	$\rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$	+1.33
$O_2(g) + 4H^+(aq) + 4e^-$	$\rightarrow 2H_2O(l)$	+1.23
$MnO_2(s) + 4H^+(aq) + 2e^-$	$\rightarrow Mn^{2+}(aq) + 2H_2O(l)$	+1.21
$Br_2(l) + 2e^-$	$\rightarrow 2Br^-(aq)$	+1.07
$AuCl_4^-(aq) + 3e^-$	$\rightarrow Au(s) + 4Cl^-(aq)$	+0.99
$NO_3^-(aq) + 4H^+(aq) + 3e^-$	$\rightarrow NO(g) + 2H_2O(l)$	+0.96
$2Hg^{2+}(aq) + 2e^-$	$\rightarrow Hg_2^{2+}(aq)$	+0.91
$Hg^{2+}(aq) + 2e^-$	$\rightarrow Hg(l)$	+0.85
$^1/_2O_2(g) + 2H^+(aq)(1.0 \times 10^{-7}\ \frac{mol}{L}) + 2e^-$	$\rightarrow H_2O(l)$	+0.82
$NO_3^-(aq) + 2H^+(aq) + e^-$	$\rightarrow NO_2(g) + H_2O(l)$	+0.81
$Ag^+(aq) + e^-$	$\rightarrow Ag(s)$	+0.80
$Hg_2^{2+}(aq) + 2e^-$	$\rightarrow 2Hg(l)$	+0.80
$Fe^{3+}(aq) + e^-$	$\rightarrow Fe^{2+}(aq)$	+0.77
$I_2(s) + 2e^-$	$\rightarrow 2I^-(aq)$	+0.54
$O_2(g) + 2H_2O(l) + 4e^-$	$\rightarrow 4OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2e^-$	$\rightarrow Cu(s)$	+0.34
$SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$	$\rightarrow H_2SO_3(aq) + H_2O(l)$	+0.20
$Sn^{4+}(aq) + 2e^-$	$\rightarrow Sn^{2+}(aq)$	+0.15
$^1/_8S_8(s) + 2H^+(aq) + 2e^-$	$\rightarrow H_2S(aq)$	+0.14
$AgBr(s) + e^-$	$\rightarrow Ag(s) + Br^-(aq)$	+0.07
$2H^+(aq) + 2e^-$	$\rightarrow H_2(g)$	0.00
$Fe^{3+}(aq) + 3e^-$	$\rightarrow Fe(s)$	−0.04
$Pb^{2+}(aq) + 2e^-$	$\rightarrow Pb(s)$	−0.13
$Sn^{2+}(aq) + 2e^-$	$\rightarrow Sn(s)$	−0.14
$AgI(s) + e^-$	$\rightarrow Ag(s) + I^-(aq)$	−0.15
$Ni^{2+}(aq) + 2e^-$	$\rightarrow Ni(s)$	−0.23
$Co^{2+}(aq) + 2e^-$	$\rightarrow Co(s)$	−0.28
$PbSO_4(s) + 2e^-$	$\rightarrow Pb(s) + SO_4^{2-}(aq)$	−0.36
$Cd^{2+}(aq) + 2e^-$	$\rightarrow Cd(s)$	−0.40
$Fe^{2+}(aq) + 2e^-$	$\rightarrow Fe(s)$	−0.41
$Cr^{3+}(aq) + e^-$	$\rightarrow Cr^{2+}(aq)$	−0.41
$2H_2O(l) + 2e^-$	$\rightarrow 2OH^-(aq)\ (1 \times 10^{-7}\ \frac{mol}{L}) + H_2(g)$	−0.42
$Cr^{3+}(aq) + 3e^-$	$\rightarrow Cr(s)$	−0.74
$Zn^{2+}(aq) + 2e^-$	$\rightarrow Zn(s)$	−0.76
$2H_2O(l) + 2e^-$	$\rightarrow H_2(g) + 2OH^-(aq)$	−0.83
$SO_4^{2-}(aq) + H_2O(l) + 2e^-$	$\rightarrow SO_3^{2-}(aq) + 2OH^-(aq)$	−0.92
$Al^{3+}(aq) + 3e^-$	$\rightarrow Al(s)$	−1.66
$Mg^{2+}(aq) + 2e^-$	$\rightarrow Mg(s)$	−2.38
$Na^+(aq) + e^-$	$\rightarrow Na(s)$	−2.71
$Ca^{2+}(aq) + 2e^-$	$\rightarrow Ca(s)$	−2.76
$Ba^{2+}(aq) + 2e^-$	$\rightarrow Ba(s)$	−2.90
$K^+(aq) + e^-$	$\rightarrow K(s)$	−2.92
$Li^+(aq) + e^-$	$\rightarrow Li(s)$	−3.05

INCREASING STRENGTH OF REDUCING AGENTS

e: Unless otherwise indicated
— all ions in this table are in aqueous solution
— all concentrations are 1.0 mol/L and all gases are at 101 kPa pressure
— $E°$ values have been measured at 298 K (25°C)

PERIODIC CHART OF THE ELEMENTS

KEY

ATOMIC NUMBER → 1 H ← SYMBOL OF THE ELEMENT
2.1 ← ELECTRONEGATIVITY
NAME OF THE ELEMENT → hydrogen 1.01 ← ATOMIC MASS

BASED ON $^{12}_{6}C$

( ) INDICATES MASS OF THE MOST STABLE ISOTOPE

NOTE: The Legend at right denotes the physical state of the elements at 101 kPa and 298 K (25°C)

LEGEND

SOLID

LIQUID

GAS

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA or O
1 H 2.1 hydrogen 1.01															2 He — helium 4.00
3 Li 1.0 lithium 6.94	4 Be 1.5 beryllium 9.01									5 B 2.0 boron 10.81	6 C 2.5 carbon 12.01	7 N 3.0 nitrogen 14.01	8 O 3.5 oxygen 16.00	9 F 4.0 fluorine 19.00	10 Ne — neon 20.17
11 Na 0.9 sodium 22.99	12 Mg 1.2 magnesium 24.31									13 Al 1.5 aluminum 26.98	14 Si 1.8 silicon 28.09	15 P 2.1 phosphorous 30.97	16 S 2.5 sulphur 32.06	17 Cl 3.0 chlorine 35.45	18 Ar — argon 39.95
19 K 0.8 potassium 39.10	20 Ca 1.0 calcium 40.08	21 Sc 1.3 scandium 44.96	22 Ti 1.5 titanium 47.90	23 V 1.6 vanadium 50.94	24 Cr 1.6 chromium 52.00	25 Mn 1.5 manganese 54.94	26 Fe 1.8 iron 55.85	27 Co 1.8 cobalt 58.93	28 Ni 1.8 nickel 58.71	29 Cu 1.9 copper 63.55	30 Zn 1.6 zinc 65.38	31 Ga 1.6 gallium 69.74	32 Ge 1.8 germanium 72.59	33 As 2.0 arsenic 74.92	34 Se 2.4 selenium 78.96	35 Br 7.8 bromine 79.90	36 Kr — krypton 83.80
37 Rb 0.8 rubidium 85.47	38 Sr 1.0 strontium 87.62	39 Y 1.3 yttrium 88.91	40 Zr 1.4 zirconium 91.22	41 Nb 1.6 niobium 92.91	42 Mo 1.8 molybdenum 95.94	43 Tc 1.9 technetium 98.91	44 Ru 2.2 ruthenium 101.07	45 Rh 2.2 rhodium 102.91	46 Pd 2.2 palladium 106.40	47 Ag 1.9 silver 107.87	48 Cd 1.7 cadmium 112.41	49 In 1.7 indium 114.82	50 Sn 1.8 tin 118.69	51 Sb 1.9 antimony 121.75	52 Te 2.1 tellurium 127.60	53 I 2.5 iodine 126.90	54 Xe — xenon 131.30
55 Cs 0.7 cesium 132.91	56 Ba 0.9 barium 137.33	57-71	72 Hf 1.3 hafnium 178.49	73 Ta 1.5 tantalum 180.95	74 W 1.7 tungsten 183.85	75 Re 1.9 rhenium 186.21	76 Os 2.2 osmium 190.20	77 Ir 2.2 iridium 192.22	78 Pt 2.2 platinum 195.09	79 Au 2.4 gold 196.97	80 Hg 1.9 mercury 200.59	81 Tl 1.8 thallium 204.37	82 Pb 1.8 lead 207.19	83 Bi 1.9 bismuth 208.98	84 Po 2.0 polonium (209)	85 At 2.2 astatine (210)	86 Rn — radon (222)
87 Fr 0.7 francium (223)	88 Ra 0.9 radium 226.03	89-103	104 Rf — rutherfordium (260)	105 Ha — hahnium (260)	106 — (263)	107 —											

57 La 1.1 lanthanum 138.91	58 Ce 1.1 cerium 140.12	59 Pr 1.1 praseodymium 140.91	60 Nd 1.2 neodymium 144.24	61 Pm — promethium (145)	62 Sm 1.2 samarium 150.35	63 Eu — europium 151.96	64 Gd 1.1 gadolinium 157.25	65 Tb 1.2 terbium 158.93	66 Dy — dysprosium 162.50	67 Ho 1.2 holmium 164.93	68 Er 1.2 erbium 167.26	69 Tm 1.2 thulium 168.93	70 Yb 1.1 ytterbium 173.04	71 Lu 1.2 lutetium 174.97
89 Ac 1.1 actinium (227)	90 Th 1.3 thorium 232.04	91 Pa 1.5 protactinium 231.04	92 U 1.7 uranium 238.03	93 Np 1.3 neptunium 237.05	94 Pu 1.3 plutonium (244)	95 Am 1.3 americium (243)	96 Cm — curium (247)	97 Bk — berkelium (247)	98 Cf — californium (251)	99 Es — einsteinium (254)	100 Fm — fermium (257)	101 Md — mendelevium (258)	102 No — nobelium (259)	103 Lr — lawrencium (260)

DATE DUE SLIP

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